Description

Current/voltage converter arrangement

5   The present invention relates to a current/voltage converter
     arrangement in accordance with the preamble of the independ-
     ent claim 1. The present invention relates in particular to a
     current/voltage converter arrangement for a switched-mode
     power supply.
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     A multiplicity of apparatus used both in industry and private
     households, or generally consumers of electrical energy, use
     not only the traditional mains voltage with a mains fre-
     quency of 50 Hz but also, increasingly, further voltages and
15   currents with other frequencies which are adapted to the
     respective applications. Accordingly, electrical adaptations
     from the mains voltage with the mains frequency of 50 Hz
     which is provided by the mains have to be carried out for the
     corresponding electrical consumers. Current/voltage converter
20   arrangements are usually used in such adaptation operations.
     In particular, switched-mode power supplies are also used in
     this case. Customary components of such current/voltage con-
     verter arrangements and in particular of switched-mode power
     supplies are rectifiers, transformers, storage capacitors,
25   smoothing inductors and similar structural components.

     Known current/voltage converter arrangements, in particular
     for switched-mode power supplies, are usually formed by a
     current/voltage input region, a current/voltage output region
30   and a transformer device provided in between. The cur-
     rent/voltage input region has first and second input termi-
     nals which serve for taking up a primary AC current or pri-
     mary current and/or a primary AC voltage or primary voltage,
     the primary current or the primary voltage being modulated in
35   particular with a specific input frequency, for example of 50
     Hz. The current/voltage output region serves to provide

and/or output a secondary current and/or a secondary voltage which, in particular, is converted with respect to the primary current and/or the primary voltage. The conversion itself is realized by the transformer device provided. The latter thus serves for the current/voltage conversion and has a primary side having a primary inductance with a first and a second input terminal. Furthermore, the transformer device has a secondary side having an inductive secondary inductance coupled to the primary inductance.

In known complete systems for current/voltage conversion, it is necessary, moreover, to provide further components by means of which, in particular, a power adaptation is also effected. Furthermore, specific rectifier components are necessary. All these components have and realize specific power losses.

The invention is based on the object of specifying a current/voltage converter arrangement which can realize a current/voltage conversion with particularly low power losses in a particularly simple yet reliable manner.

In the case of a current/voltage converter arrangement of the type mentioned in the introduction, the object is achieved according to the invention by means of the characterizing features of the independent claim 1. The dependent subclaims respectively relate to advantageous developments of the current/voltage converter arrangement according to the invention.

The current/voltage converter arrangement according to the invention is characterized by the fact that a first switch device with a first - in particular essentially unidirectional - bypass function is provided between the first input terminal of the primary side of the transformer device and the first input terminal of the current/voltage input region,

a second switch device with a second - in particular essentially unidirectional - bypass function is provided between the second input terminal of the primary side of the transformer device and the second input terminal of the current/voltage input region, the first bypass function and the second bypass function are respectively in parallel with a first switch mechanism of the first switch device and in parallel with a second switch mechanism of the second switch device and formed and/or arranged in such a way that the respective switch mechanism of the respective switch device can be bypassed in each case in a controllable manner with an electrical conduction path. It is furthermore provided that the first switch device and the second switch device are formed in antiseries with respect to one another, and the first switch device and the second switch device can be switched on and/or off in a controlled manner, in a manner dependent on the primary potential and/or on the primary current, in a clocked manner with a comparatively high or higher switching frequency with respect to the input frequency, and in an alternative manner with respect to one another.

By means of the features provided according to the invention, in the case of a current/voltage converter arrangement according to the present invention, the number of components affected by critical power losses is critically reduced compared with the prior art, but at the same time a reliable current/voltage conversion with power factor adaptation and/or, if appropriate, rectification can be realized.

Thus, a central idea of the present invention is to provide a respective switch device instead of an explicit rectifier device on the input side or primary side of the transformer and instead of a corresponding power factor adaptation circuit between the primary side of the transformer device and the input for the mains voltage, with the result that a se-

rial sequence comprising first switch device, primary induc-
tance of the transformer device and second switch device is
produced, the first switch device and the second switch de-
vice in each case additionally having a bypass function and
5   being formed in antiseries with respect to one another. The
first switch device and the second switch device can be
switched on and/or off in an alternative manner with respect
to one another, use being made of a high or higher switching
frequency in comparison with the input frequency of the pri-
10   mary current or the primary voltage. Furthermore, a con-
trolled, mutually alternative switch-on and/or -off which is
dependent on the primary potential and/or on the primary
current is produced for the two switch devices. Consequently,
as viewed overall, a current/voltage conversion with at the
15   same time rectification and power factor adaptation is real-
ized, to be precise without having to use the multiplicity of
lossy components known in the prior art.

In a preferred embodiment of the current/voltage converter
20   arrangement according to the invention, it is provided that
the first switch mechanism and the first bypass function of
the first switch device are respectively formed in antiseries
with respect to the second switch mechanism and with respect
to the second bypass function of the second switch device.
25   The antiseries arrangement of the first and second switch
devices with respect to one another is realized in this way.

In a further advantageous embodiment of the current/voltage
converter arrangement according to the invention, the first
30   switch mechanism and/or the second switch mechanism are
formed as a bipolar transistor or an IGBT.

The first and/or the second bypass function has to be addi-
tionally and explicitly formed, in particular as a diode
35   device.

It is particularly advantageous, however, if the first and/or the second switch mechanism are formed as MOSFET.

It is particularly advantageous in particular when, but also in other cases, the first bypass function and/or the second bypass function are formed as a parasitic diode device and in particular as a parasitic body diode. This is because the bypass function can then be formed inherently without the explicit provision of additional structural parts and solely on account of the nature of, for example, the switch mechanisms or switch devices provided.

The current/voltage converter arrangement according to the invention is configured in a particularly advantageous manner if the first and the second switch device can be connected or are connected directly to the primary voltage. The input and rectifier stages provided in the case of the prior art are thereby obviated.

As an alternative or in addition, it is provided that the first and the second switch device in interaction form a synchronous rectifier or can be operated or are operated as such. This measure also obviates the lossy explicit rectifier device provided in the case of the prior art on the primary side of the transformer device.

In this case, but also otherwise, it is provided, in particular, that the first and the second bypass function are formed and/or arranged in such a way that in interaction they can be operated or are operated as a primary-side rectifier device.

The transformer device can be used particularly effectively as an energy store, according to the invention, when the transformer device is constructed and arranged and can be operated and/or is operated essentially in accordance with the flyback converter principle.

Various configurational forms are afforded with regard to the transformer device.

5   In accordance with one preferred embodiment, it is provided that the secondary inductance is formed by an individual inductance. As an alternative, it may be provided that the secondary inductance is formed by a first secondary inductance in a second secondary inductance.

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In accordance with a further preferred embodiment of the current/voltage converter arrangement according to the invention, it is provided that a secondary-side rectifier device is provided between the secondary inductance and the current/voltage output region.

15   rent/voltage output region.

In this case, various embodiments are again afforded for the secondary or secondary-side rectifier device.

20   In a preferred embodiment, the secondary-side rectifier device is formed as an arrangement of diode devices.

In addition, or as an alternative, it is provided that the secondary-side rectifier device is formed as a rectifier half-bridge with two diode devices, particularly if the secondary inductance is formed as an individual inductance.

25   half-bridge with two diode devices, particularly if the secondary inductance is formed as an individual inductance.

In another alternative embodiment of the invention, it is provided that the secondary or secondary-side rectifier device is formed as a rectifier full bridge with four diode devices, in particular when the secondary inductance is formed by a first secondary inductance and a second secondary inductance.

35   It is particularly advantageous if the diode devices of the secondary-side rectifier device are formed by MOSFETs.

In this case, it is particularly advantageous if the secondary-side rectifier device can be operated or is operated in the synchronous rectifier mode.

In another alternative embodiment of the present invention, it is provided that a capacitor device for smoothing and/or for energy storage is provided between the current/voltage output region and the secondary-side rectifier device in parallel with first and with second output terminals of the current/voltage output region.

In this case, it is particularly preferred that a serial isolating device is provided between the capacitor device and the secondary-side rectifier device, and that this serial isolating device is formed to prevent and/or to suppress, in a controlled manner in a manner that is potential-dependent and/or phase-dependent on the primary current and/or on the primary voltage, a direct application of the primary voltage to the capacitor device.

In this case, it is advantageously provided that the serial isolating device has a switch device or is formed as such.

It is particularly advantageous if, in accordance with a further advantageous embodiment of the present invention, the serial isolating device has a MOSFET or is formed as such.

In addition or as an alternative, it may be provided that the serial isolating device is inversely clocked and/or inversely controlled or inversely clockable and/or inversely controllable with respect to the first and with respect to the second switch device.

These and further aspects of the present invention are also explained in more detail on the basis of the remarks below:

An ever increasing proportion of the electrical energy con-
sumers in a household no longer requires the traditional form
of electrical energy with a 50 Hz sinusoidal voltage, but
5   rather requires voltages, currents and frequencies which are
adapted to the respective process.

This adaptation currently uses rectifiers, transformers,
switched-mode power supplies, storage capacitors and smooth-
10   ing inductors which, from the mains connection point up to
the consumer, form a plurality of cascaded energy conversion
and storage stages. During the flow of energy, losses arise
in each stage, so that the maximum efficiency that can be
achieved decreases as the number of stages increases.
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This situation was aggravated further by the legislator
through the introduction of the new EU standard EN61000-3-2
for power factor correction PFC, because an additional energy
conversion stage becomes necessary.
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In accordance with the present-day prior art, mains connec-
tion assemblies comprise a filter circuit, a rectifier with
downstream-connected step-converter, intermediate circuit
capacitors, invertor, inductive transformer, rectifier,
25   smoothing inductor and filter. These energy conversion and
storage stages are necessary in order to generate an adjust-
able DC voltage from the AC input voltage.

In this configuration, a maximum efficiency limit of nowadays
30   on average 72% can be achieved on account of the various
energy conversion stages.

A study of PC power supplies showed that the use of the best
power semiconductors in a conventional system enables the
35   power loss to be reduced in such a way as to make it possible
to dispense with heat sinks and fans. At the same time, this

study proved that a further reduction of the power loss is not possible through a further optimization of components, but only through a new architecture.

5   The typical input architecture nowadays comprises e.g. a diode bridge for the rectification of the mains voltage and a downstream-connected boost converter for the power factor correction.

10   The power loss of the diode bridge is a significant portion of the total losses in the system. Said diode bridge often has to be cooled by means of a heat sink.

The number of components is increased by the present-day
15   input architecture, thus reducing the reliability of the system.

A further problem resides in the surge current problem area when the switched-load power supply is first switched on.
20   Before the power supply is switched on, all the energy stores such as inductances and capacitors are empty. When the power supply is switched on, the mains voltage is abruptly connected to the system. This leads to very large current surges during the charging of the capacitors. Said current surges
25   may destroy components, principally the semiconductors.

The solution proposed according to the invention comprises, inter alia, a novel converter with the functions of present-day mains rectifiers and power factor correctors or PFC
30   boost.

A number of central aspects of the invention are characterized by the fact that two primary-side switch devices or switches, without rectifiers or a diode bridge, are connected
35   directly to the mains or to the primary voltage, that these two primary-side switch devices are connected in antiseries

with respect to one another and in series with the primary-side inductance or winding of the transformer or the transformer device, and that, in particular, one or a plurality of secondary-side switch devices provide for the electrical
5 isolation of an output capacitor as long as current flows through the primary-side inductance or winding of the transformer device.

The present invention is explained in more detail below on
10 the basis of preferred embodiments with reference to the accompanying drawings.

Fig. 1, 2   diagrammatically show circuit arrangements which are used in the area of current/voltage conver-
15   sion in the case of the prior art.

Fig. 3   shows a circuit arrangement of a first embodiment of the current/voltage converter arrangement according to the invention.
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Fig. 4A-5B   diagrammatically elucidate the functioning of the current/voltage converter arrangement according to the invention as shown in fig. 3.

25 Fig. 6   shows an alternative embodiment of the current/voltage converter arrangement according to the invention.

Fig. 7   shows a detail of another embodiment of the cur-
30   rent/voltage converter arrangement according to the invention.

In the case of the figures and embodiments described below, structurally and/or functionally identical or similar ele-
35 ments or assemblies are designated by the same reference

symbols. A detailed description in respect thereof is not
repeated every time they occur.

5   One embodiment of the circuit arrangement for the cur-
rent/voltage converter arrangement 1 according to the inven-
tion with the proposed "Reverse-Blocking Flyback" is illus-
trated in fig. 3.

It comprises a transformer device T with a primary side TP
10   and a secondary side TS, a current/voltage input region E for
connecting the primary side TP to the mains V1 and a cur-
rent/voltage output region for connecting the secondary side
TS to a load or the like.

15   The current/voltage input region E has a first input terminal
E1 and a second input terminal E2. The current/voltage output
region A has a first output terminal A1 and a second output
terminal A2.

20   The primary side TP of the transformer device T also has
first and second input terminals TE1 and TE2. A first switch
device T1 is provided between the first input terminal TE1 of
the primary side TP of the transformer device T and the first
input terminal E1 of the current/voltage input region E. A
25   second switch device T2 is provided between the second input
terminal TE2 of the primary side TP of the transformer device
T and the second input terminal E2 of the current/voltage
input region E.

30   The first switch device T1 is formed by a first switch ele-
ment TM1 or switch mechanism TM1 in the form of a MOSFET and
by the body diode BD1 inherent therewith as first essentially
unidirectional bypass function TD1, by means of which it is
possible to realize an electrically conductive bypass path
35   for bypassing the first switch mechanism TM1 in a controlla-
ble manner. The second switch device T2 is formed by a second

switch element TM1 or switch mechanism TM1 in the form of a MOSFET and by the body diode BD2 inherent therewith as second essentially unidirectional bypass function TD2, by means of which it is possible to realize an electrically conductive

5   bypass path for bypassing the first switch mechanism TM2 in a controllable manner.

The first switch mechanism TM1 has, as a MOSFET, a first source terminal or source region s1, a first drain terminal

10   or drain region d1, a first body terminal or body region b1 and also a first gate terminal or gate region g1.

The second switch mechanism TM2 has, as a MOSFET, a second source terminal or source region s2, a second drain terminal

15   or drain region d2, a second body terminal or body region b2 and also a second gate terminal or gate region g1.

The first switch device T1 and the second switch device T2 and consequently the first switch mechanism TM1 and the first

20   bypass function TD1, on the one hand, and the second switch mechanism TM2 and the second bypass function TD2, on the other hand, are formed in antiseries with respect to one another.

25   The primary AC voltage or primary voltage Uprim and/or the primary AC current or primary current Iprim of the mains V1 can be fed to the primary side TP via the current/voltage terminals E1 and E2 of the current/voltage input region E.

30   The transformer device T has a primary inductance L1 on the primary side TP and a secondary inductance comprising a first and a second secondary inductance L1 and L2, respectively, on the secondary side. The secondary inductance as a whole has first and second output terminals TA1 and TA2, respectively.

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The antiseries-connected switch devices T1 and T2 or MOSFETs
T1, T2 with parasitic body diodes BD1 and BD2 as bypass func-
tions TD1 and TD2 are directly connected to the mains V1 and
thus to the primary AC voltage or primary voltage Uprim. In
5   this case, the pure MOSFETs - without the parasitic body
diodes BD1, BD2 - form the switching elements or switching
mechanisms TM1, TM2 in the sense of the invention. The sepa-
rate mains rectifier from the prior art is completely obvi-
ated, and thus so are the power losses in respect thereof.
10

For outputting power to an external load, a current/voltage
output region A with first and second output terminals A1 and
A2, respectively, is provided on the secondary side.

15 For energy storage and/or for smoothing, a capacitor device
C1 is provided in a manner connected in parallel between the
secondary side TS of the transformer device T and the cur-
rent/voltage output terminals A1 and A2.

20 A secondary-side rectifier device G2, which is formed by a
half-bridge arrangement comprising two diodes D1, D2, is
provided between the capacitor device C1 and the secondary
side TS of the transformer device T.

25 Furthermore, an isolating device T3 - which can be clocked in
a controlled manner - in the form of a MOSFET with body diode
BD3 is provided in series between the first current/voltage
output terminal A1 and the first output terminal TA1 of the
secondary side TS of the transformer device T or the secon-
30 dary-side rectifier device. The MOSFET T3 likewise has a
drain region or drain terminal d3, a source region or source
terminal s3, a body region or body terminal b3 and also a
gate region or gate terminal g3.

35 For controlling the first and second switch devices T1, T2
and the isolating device T3, provision is made of a control

device S with control terminals t1, t2, t3 for the transistors T1, T2 and T3, respectively, or for the gate terminals g1, g2 and g3, respectively, thereof.

5   The basic functioning of the current/voltage converter arrangement 1 according to the invention in accordance with fig. 3 is explained with reference to fig. 4A to 5B.

The second switch device T2 or the second MOSFET T2 is
10   switched on, as is shown in fig. 4A, if the positive half-phase of the primary voltage Uprim of the mains V1 is present at the first input terminal E1. The primary AC current Iprim or primary current Iprim flows in the current/voltage input region E from the mains V1 via the body diode BD1 of the
15   first switch device T1 or of the first MOSFET T1 into the primary inductance L1 or primary winding L1 of the transformer T and via the channel of the second switch device T2 back to the mains V1.

20   On the side of the secondary side TS of the transformer device, the transistor T3 remains switched off. As a result, no current flow can arise on the secondary side. The transformer T with the primary inductance L1 and the secondary inductances L2, L3 stores magnetic energy.
25

The transistor T2 is switched off, as is shown in fig. 4B. The transformer windings L1, L2, L3 change their polarity on account of the law of induction. The transistor T3 is switched on. The diode D1 is positively biased, as a result
30   of which a current flow of the secondary current Isec arises from the secondary side TS, to be precise from the winding L2 via the diode D1 and the channel of T3 to the capacitor C1 and back to the other end of the winding L2. The transformer T outputs the stored energy into the load and the capacitor
35   C1.

During the negative half-cycle or half-phase at the first input terminal E1, the transistor T1 is switched on, as is shown in fig. 5A. The primary current Iprim flows from the mains V1 via the body diode BD2 of T2 into the primary wind-
5   ing L1 of the transformer T and via the channel of T1 back to the mains V1.

On the secondary side TS, the transistor T3 remains switched off. As a result, no current flow of the secondary current
10   Isec can arise on the secondary side TS. The transformer T stores magnetic energy.

The transistor T1 is then switched off, as is shown in fig. 5B. The transformer windings L1, L2, L3 change their polarity
15   on account of the law of induction. The transistor T3 is switched on in a controlled manner. The diode D2 is posi- tively biased, as a result of which a current flow of the secondary current Isec arises on the secondary side TS, to be precise from the winding L3 via the diode D2 and the channel
20   of T3 to the capacitor C1 and back to the other end of the winding L3. The transformer T outputs the stored energy into the load and the capacitor C1.

The power factor correction is realized by pulse width modu-
25   lation or by frequency modulation or by both. The rectifica- tion and PFC are realized in this way.

Fig. 6 shows another embodiment of the current/voltage con- verter arrangement 1 according to the invention. In the case
30   thereof, the secondary inductance L2 of the transformer de- vice T is an individual inductance or individual winding. The secondary-side rectifier device G2 is a rectifier full bridge comprising four diodes D1, D2, D3, D4.

35   If the switches T1, T2 are designed as MOSFETs, they can be operated as a synchronous rectifier. If the respective body

diode BD1, BD2 is intended to conduct, the respective channel of the respective MOSFET TM1, TM2 is opened by the respective gate g1, g2. As a result, the current Iprim is divided between the body diode BD1, BD2 and the channel. This leads to
5   a low power loss caused by the Reverse-Recovery behavior of the respective body diode BD1, BD2, since a smaller current flows and has to commutate in said body diode.

If the channel resistance has a smaller value than the body
10   diode forward voltage divided by flowing current, the entire current flows only through the channel of the MOSFET. This leads to an even lower power loss during the commutation of the body diode, which is obviated in this case.

15   The MOSFETs T1 and T2 can be operated in the synchronous rectifier mode.

The diodes D1 and D2 of the secondary-side rectifier device may be designed as MOSFETs in the synchronous rectifier mode.
20

If said diodes D1 and D2 are designed as MOSFETs, a transistor T3 or an isolating device T3 may be obviated, under certain circumstances, if isolation is then inherently effected by D1 and D2.
25

If the primary-side switches T1, T2 are designed as MOSFETs, they may be operated as synchronous rectifiers. If the respective body diode BD1, BD2 is intended to conduct, the channel of the respective MOSFET TM1, TM2 is opened by the
30   respective gate g1, g2. As a result, the current Iprim is divided between the body diode BD1 or BD2, respectively, and the channel. This leads to a low power loss caused by the reverse recovery behavior of the respective body diode BD1 or BD2, since a smaller current flows and has to commute in said
35   body diode.

If the channel resistance has a lower value than the quotient of forward voltage dropped across the body diode divided by flowing current, the entire current flows only through the channel of the respective MOSFET TM1, TM2. This leads to an
5   even lower power loss during the commutation of the respective body diode BD1 or BD2, which is obviated in this case.

The primary-side MOSFETs TM1, TM2 may, under certain circumstances, be operated in the synchronous rectifier mode.
10

All the secondary-side diodes D1, D2, D3, D4 may likewise be designed as MOSFETs in the synchronous rectifier mode.

If the secondary-side diodes D1, D2, D3, D4 are designed as
15   MOSFETs, then no secondary-side transistor T3 is required, under certain circumstances.

Advantages of the solutions proposed are:

20   - reduced number of components in the system,
     - higher reliability on account of fewer components,
     - lower costs on account of fewer components, and
     - higher efficiency together with little power loss.

25   What may be disadvantageous, under certain circumstances, is a 100Hz/120Hz voltage ripple at the output capacitor C1 at relatively low output voltages (< 100 V). This disadvantage can be eliminated by using a low-power active filter, as is shown in fig. 7.
30

The energy absent during the mains zero crossings is drawn from the capacitor C2 and pumped into the output capacitor C1. C2 is charged via the inductor L and the switches S1 and S2 if there is enough energy from the mains.

According to the invention, the transformer device T additionally forms the function of the inductor between the primary-side rectifier 20 and the PFC 30 of the known converter arrangement 100 from fig. 1.

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In addition to the secondary-side rectification, the secondary-side diodes D1, D2, D3, D4 also partially or completely perform the function of the PFC diodes provided in the case of the prior art.

List of reference symbols

	1	Current/voltage converter arrangement according to the invention
5	10	Filter, mains filter
	20	Primary-side rectifier
	30	Power factor converter, PFC
	40	Invertor
	50	Secondary-side rectifier
10	60	Filter
	70	PFC controller
	80	Invertor controller
	100	Conventional current/voltage converter arrangement
15		
	A1	Current/voltage output terminal, output terminal
	A2	Current/voltage output terminal, output terminal
	BD1	Body diode
	BD2	Body diode
20	BD3	Body diode
	b1	Body terminal with respect to T1
	b2	Body terminal with respect to T2
	b3	Body terminal with respect to T3
	C1	Capacitor device, smoothing capacitor, capacitor for energy storage
25		
	C2	Capacitor
	D1	Diode device
	D2	Diode device
	D3	Diode device
30	D4	Diode device
	d1	Drain terminal with respect to T1
	d2	Drain terminal with respect to T2
	d3	Drain terminal with respect to T3

	E1	Current/voltage input terminal, input terminal
	E2	Current/voltage input terminal, input terminal
	G2	Secondary-side rectifier device
	g1	Gate terminal with respect to T1
5	g2	Gate terminal with respect to T2
	g3	Gate terminal with respect to T3
	Iprim	Primary AC current, primary current
	Isec	Secondary current
	L	Inductor
10	L1	Primary inductance
	L2	Secondary inductance, first secondary inductance,
	L3	Secondary inductance, second secondary inductance
15	S	Control device for T1, T2, T3
	s1	Source terminal with respect to T1
	s2	Source terminal with respect to T2
	s3	Source terminal with respect to T3
	T	Transformer device, transformer
20	T1	Switch device, first switch device
	T2	Switch device, second switch device
	T3	Isolating device
	t1	Control line with respect to T1
	t2	Control line with respect to T2
25	t3	Control line with respect to T3
	TD1	First bypass function, first diode with respect to T1
	TD2	Second bypass function, second diode with respect to T2
30	TA1	First output terminal of the secondary side TS
	TA2	Second output terminal of the secondary side TS
	TE1	First input terminal of the primary side TP
	TE2	Second input terminal of the primary side TP
	TM1	First switching element

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TM2	Second switching element
TP	Primary side of the transformer device T
TS	Secondary side of the transformer device T
Uprim	Primary AC voltage, primary voltage
Usec	Secondary voltage
V1	Mains voltage, mains voltage source
Z1	Diode
Z2	Diode
vin	Input frequency
vsw	Switching frequency

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